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# Adaptive-Reuse of Historic Industrial Buildings and Sites in China*

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**Abstract:** The paper analyzes the definite place of industrial building in the history of urban development. Due to the development of urban economy and the transition of the traditional industrial structure, many historic cities and towns both at home and abroad have witnessed a large-scale "demolition" and abandonment of industrial buildings in urban renewal during last 30 years. Consequently, it has been leading to the discontinuity of urban cultural and historic context. The paper discusses and expounds the classification, possible ways and measures for adaptive-reuse and redevelopment for historic industrial buildings, sets up an analytical framework of designing methods on renovation of historic industrial sites and buildings and several proposals on practice for further considerations are put forward.

**Key words:** historic industrial building, heritage, adaptive-reuse, urban redevelopment

## 1 Relevant Concepts of Historic Industrial Buildings and Sites

### 1.1 Historic industrial buildings and sites

Historic industrial buildings and sites refer to the buildings, constructions, and their sites specially used for industry, storage, and transportation, which appeared after the Industrial Revolution. For various reasons, some have lost their original functions and some even have already ruined.

Industrial buildings refer to the factory buildings of industrial production, manufactory and maintenance, warehouses, service buildings, constructions, industrial facilities and their infrastructure.

Storage buildings refer to the urban industrial and commercial warehouses and facilities etc.

Transportation buildings refer to the docks for transportation, station buildings, warehouses, shipyards, loading and unloading facilities and other accessory buildings.

### 1.2 Classification of historic industrial buildings[1]

#### 1.2.1 Classification by space

According to the different spatial features of historic industrial buildings, they can be classified into three categories:

1) Large span type refers to buildings with large interior space, and most of its supporting structures are giant steel frames, arches, bents etc. forming huge, open, and pillarless interior space;

2) Regular type refers to buildings with interior space lower than the first type, but huge and open, and most of them are frame structured multistoried buildings;

3) Special type refers to buildings and constructions with special forms such as gas tankers, granary, cooling towers, and shipyard etc. And usually they have distinctive appearances showing their special functions.

#### 1.2.2 Classification by function and attribution

The style, pattern, material and structure or special construction method of some industrial buildings may have the academic research value in architectural history. E.g., the turbine workshop of Berlin General Electric Company designed by Peter Behrens in 1908 is regarded as the masterpiece of modern architecture[2] (see Fig.1). This building uses reinforced concrete structure and partial glass curtain wall. It's plainly and naturally shaped, and is regarded as the first real modern architecture by the west. Another example is located in Shanghai, China where many industrial buildings with historic highlights have been preserved too. For instance, Yang Shupu Gas Works, whose predecessor was Shanghai Gas Co. Ltd, the earliest of its kind, whose carbonization chamber is the first steel-framed factory building in China. No. 1 furnace chamber is the earliest steel-framed multi-storied factory building in China,

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and No. 5 furnace chamber was the highest steel-framed factory building in China then[3].

**Fig**.1 Turbine workshop of Berlin General Electric Company designed by Peter Behrens, Germany

These buildings and their areas themselves are of historic landmark value and significance. Often they have witnessed the historical process of the economy and industrial development of a city, an area, and even a country, such as Ruhr industrial area which used to be a German industrial and military equipment center in history[4] (see Fig.2). Shanghai Suzhou River backsides industrial buildings and sites have recorded the ups and downs of Shanghai industry over a hundred years.

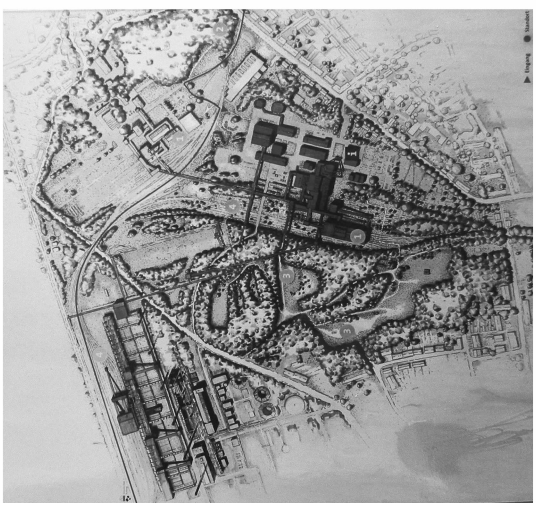

**Fig**.2 Duisburg Nord Landscape Park designed by Peter Latz, Ruhr, Germany

Buildings and sites are both of significant value, and some buildings might still be in use, but their special shape, color and huge volume have remarkable visual effect on the urban landscape and environment. In this respect, the redevelopment of Boston Coastal Cement Factory and its surroundings are fairly typical, because it provides people with an excellent example of the organic combination of a heavy-industrial facility and urban waterside area[5] (see Fig.3).

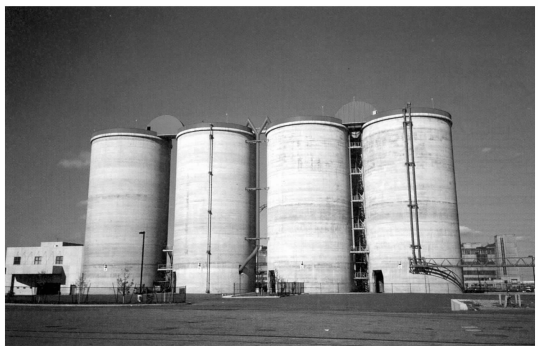

**Fig**.3 Boston Coastal Cement Factory

### 1.3 Regeneration of urban historic industrial buildings and sites

#### 1.3.1 Causes for regeneration

There are three causes for the regeneration of historic industrial buildings and sites.

With the advent of the industrial age, great changes have taken place to the global economic structure. In cities of the developed countries, the traditional manufacture has declined, while in developing countries it is moving gradually from the inner city to the outer places. In these cities, areas of industry, water or land transportation, warehouse and buildings involved are affecting each other, like domino effect, if one of them declines, the others will follow the step gradually.

The way of production and transportation is changing and has caused the function, distribution, and infrastructure facility of the original buildings and areas unable to meet the new demand, hence regional function has declined.

With the urban expansion, the original land for industry is gradually encircled in the urban central belt; moreover, the value differences of different land zones and environment pollution prevention lead to the need of the readjustment of urban industrial distribution.

Quite often the above three factors are overlapping. Whether it is "the Renovation Plan" led by the government involved, and environment pollution prevention; or the function transfer caused by the regionalization of land and graded land rent, these causes are the opportunities for regeneration.

#### 1.3.2 Pattern for regeneration

The adoption of regeneration pattern will affect the original urban spatial landscape form and the existence

of many historic industrial buildings and sites. At the same time, the effect of regeneration investment and environment protection will be greatly different. In the world, the noticeable change of concept and development pattern are from total pull down and total buildup to recent adaptive renovation giving priority to regeneration.

1) Priority in new buildings

This kind of development is out of economic consideration, and its development method is mainly large-scale renovation. It occurred mostly in the early period of urban renovation movement, such as Yokohama "Minato Mirai 21" (MM'21) etc.[6] (see Fig.4). This value preference could also be reflected in some development cases in the early period, such as the first phase of London Dockland renovation.

**Fig**.4 Yokohama Minato Mirai 21, Japan

2) Priority in regeneration and redevelopment

Now this method is prevailing in USA and Europe. The values of history, culture, landscape or ecology etc. of the industrial base have been given proper consideration. In the development, the method adopted is preservation and regeneration, and protective development is applied to the places rich in industrial culture and industrial landscape value. Successful cases can be found in the redevelopment of Granville Island of Vancouver, Canada etc[7].

### 1.3.3 Current situation and tendency of China

Because the urban industrial structure in China is unbalanced, since the beginning of 1990s, almost all the major and middle-sized cities have revised their urban overall planning and begun a new round of urban structural readjustment in accordance with the development of socio-economic transition period. Take Beijing as an example, according to Beijing Urban Master Planning, "within 20 years, the renovation and transformation of plants and workshops of pollution and disturbing residents in the city will be basically accomplished." Over 130 industrial manufacturers will be moved out of the inner city, and many more industrial lands will face readjustment and regeneration for the third industry. Another example is Shanghai, according to 1997's Shanghai Land Use Master Plan, for a rather long time, the focus of urban renovation is the industrial land displacement of 66.2 $km^2$ in the central city. By 2010, in the central city, 1/3 factories of nonpolluting urban industry and hi-tech industry will be preserved and developed, 1/3 factories will be transformed into the land for the third industry, 1/3 factories will be moved out to the industrial concentration in the suburbs and the outer suburbs through displacement.

From the above, we can see the cities in China are entering a development phase with regeneration and redevelopment of industrial buildings and sites.

## 2 Adaptive-Reuse in Redevelopment

Because of the influence of energy, resources, the awareness of environment protection and historical protection, after difficult exploration, the countries and areas in America and Europe have entered post-industry society. From the beginning of 1960s, they began to pay attention to the adaptive-reuse and redevelopment of historic industrial buildings and sites; therefore, the influence is extending gradually.

In China, the readjustment to historic industrial buildings began approximately in late 1980s. For instance, the multi-storied factory building of Beijing Watch Manufactory has been rebuilt as "Shuangan Department Store"(see Fig.5). But because the economic problems, technology and values, in urban renovation, mostly the method adopted is total pull down and total buildup. The new idea which is prevail abroad is adaptive regeneration, which is applied only

**Fig**.5 Shuangan Department Store used to be the building of Beijing Watch Manufactory

in few cases in China, with the problems of being small in scale, imperfect in method, unsystematic in theory, and little in influence. But at present, the architectural professionals and the circle of theory have given the matter a certain attention. Some academic periodicals and works have introduced and commented on the new ideas to a certain degree.

## 3 Possible Way for Adaptive-Reuse

Because the factors such as historic significance, spatial features, structural state of historic industrial buildings and the current urban environment are real existence, the regeneration and redevelopment to these buildings should be based on these conditions accordingly, and find and use the positive factors, and explore the possibility of regeneration, and enable them to play proper roles in cities.

### 3.1 Historic and cultural value of buildings and sites

The development method is mainly applied to the buildings and sites of unique historic and cultural value, that is, rich in both historic significance and special landscape; therefore, remarkable effect can often be achieved from the redevelopment of them, which can be developed into the resorts of sightseeing. In these development projects, while people fulfilling their own need, they also obtain an opportunity to travel back in history. For example, the Zollverein Coking Plant in Essen, Germany(see Fig.6) is the one which uses the original industrial site and is of Ruhr industrial cultural characteristics. Thus, the old and the new elements have been cleverly combined. Now it has been listed as UNESCO's world cultural heritage.

**Fig**.6 Zollverein Coking Plant in Essen

### 3.2 Regional function requirement of the buildings

The location of historic buildings is an important factor affecting the renovation of the building itself. The location factor determines the land value and redevelopment investment profit of the building, to a large degree, affecting its use greatly. According to the function requirement of the buildings' location, they can be transformed into park, museum, school, library, residence or the office buildings of various cultural, or executive organization, hotel, restaurants and shopping centers etc.

### 3.3 Spatial and structural potential development of the original buildings

Find the spatial and structural potential of the original historic buildings by the way of functional replacement of interior space, or reconstruction of the original space; thus, find a reasonable and workable use for them. Because the spatial conditions and structural types of the original historic industrial buildings are different, the full use of their current conditions and the reasonable and workable renovation method adopted are very necessary.

## 4 Renovation Design of Historic Industrial Buildings and Sites

### 4.1 Spatial shape design of the renovation and extension of the buildings

#### 4.1.1 Spatial renovation

The spatial renovation of the buildings should be based on the analyses on the possible use of the renovation of the current spatial characteristics.

1) Spatial function replacement

It means that the buildings are used for other purposes with the function needing about the same space. Its feature is that there are no structural alterations to the original buildings, and only necessary reinforcement and repair are needed. The renovation focuses on skylight, circulation structure, interior and exterior decoration and the change of facilities. For example, transform buildings of large span and space into theater, assemble hall, auditorium or museum; or transform comparative lower buildings (such as multi-storied light industrial factory buildings and warehouses) into recreational or shopping center, and space for office etc. A good case in point is the recently completed immortal masterpiece, Tate Modern Art Museum, designed by Herzog & de Meuron, which is located by the Thames River in London (see Fig.7).

**Fig.7** Tate Gallery of Modern Art renovated from Bankside Power Station designed by Sir G. Scott, London, England

2) Spatial reconstruction

① Break the whole into parts: According to the need of new function, use the methods of vertical layer or horizontal partition etc. to change the large interior space into smaller ones.

● Vertical layer To the buildings with tall and large interior space, the method of interior vertical layer can be used to divide the tall space into several appropriate floors for further use. This renovation method must emphasize the coordination between the structure of the original buildings and that of the added members. The new component should not cause changes to the base and the bearing members in the upper section of the original buildings.

● Horizontal partition Without changing the original main structure, horizontal dividing walls are added to change the continuous space into many smaller ones. E.g. multi-storied, frame-structured factory buildings or warehouses with continuous space are renovated into residents etc.

② Combine parts to form a whole piece. The comparatively independent buildings are linked to form a larger continuous space through the methods of removing walls and adding connective corridors and connecting buildings by adding ceilings over them etc.

● Remove walls at the joint of buildings The connecting walls (the communal walls and the double adjoining walls), linking two adjacent buildings, are removed to form a circulating space; if the buildings are frame-structured, the non-framed structural connecting walls can be removed to form a uniform space.

● Add overlapping corridor between buildings Corridors or sky bridges are added between the adjacent buildings to establish connection within a building.

● Add ceilings over different buildings Ceilings are added at the joint of buildings. Within the space formed by added ceilings, local extension can be possible, and corridors and stairs can be built to connect the buildings. Therefore, the several original separated buildings can be linked together. As a result, the exterior space becomes interior atrium, and the usable area is multiplied.

③ Local enlargement: According to the need of new function and space, in a certain area either outside or inside a building, new spatial facilities are added such as elevator, staircase, open courtyard, atrium transformed from ceilinged small yard, corridor just next to the outer wall of a building.

④ Local removal: There are three situations.

● Removing the wall Remove the nonstructural internal wall of the original buildings to obtain larger interior space. Replace the nonstructural external wall with large glass window or open corridor for more daylight and view etc.

● Removing floor slab, beam, column Remove the local members such as floor, slab, beam, column etc. of the original multi-storied buildings, to form atrium or multi-storied lobby etc. with tall and large space; thus, colorful new space meeting the new functional need is formed. Necessary reinforcement to the structure should be conducted. The local removal to the building should not affect the solidity of the overall structure of the building.

● Removing block Remove parts of the main structure of the original building to form a new outline of the building. The method is mostly applied to recent industrial buildings.

⑤ Local rebuilding: There are two main situations.

Because of natural erosion or human damage to historic buildings, there are damages to the original building member or local structure, such as the roof, corner or gable etc. of the building. During the process of renovation, local reconstruction is needed to make it reusable on the basis of the original structure. This kind of buildings are mostly early industrial buildings, and in reconstruction design, attention should be given

to the formal, spatial, functional relationship between the newly-built part and the original building, the original structural load-bearing capacity and the necessary reinforcement etc.

According to the reconstruction design, remove and rebuild parts of the building to form new outline. These buildings are mostly recent industrial buildings, and the original architectural structure usually is strong and intact, so there is more room for improvement. But during the renovation, the above problems should be considered.

#### 4.1.2 Extension

Extension refers to the new construction parts either complementary or extended to the original architectural function, based on the original architectural structure or within the spatial area closely connected to the original building. It includes vertical and horizontal extension. In this respect, integrated consideration should be given not only to the function and utility requirement of the extension itself, but also to the connection and transition of the interior and exterior spatial forms between the extension and the original historic building.

1) Vertical extension

Add vertical layers on the top of the original building; thus, without changing the plot area, the architectural area is multiplied and the plot ratio is increased, meeting the economical need. It should be noted that this extension method will change the outline of the original building, affecting the architectural form, and its demand on the architectural structure is rather high. So in the designing process, the bearing capacity of the original structure should be considered and the structure should be reinforced etc.

2) Horizontal extension

New buildings should be adjacent or next to the original building and incorporated with the old one. In this respect, attention should be given to the functional and spatial connection between the new and the old buildings, and the affect of the new building on the current architectural structure; at the same time, protective design and construction plan should be prepared so that the new building will not cause damage to the historic building.

#### 4.1.3 The technical analysis on the methods of alteration and extension of buildings

As to various types of buildings and constructions, not every above method is applicable. Buildings and constructions of different spatial structural types have their distinctive structural features. An economical, reliable alteration or extension design plan cannot be made until the above features are fully considered and used. Otherwise, the investment will be great and it is possible to cause damage to the solidity of the original historic building. Therefore, in the early designing period, it is necessary to have the technical analysis on the possibility of the alteration or extension method according to the features of the spatial and structural types of the original buildings and constructions. In this respect, the cooperation between architects and structural engineers is the key factor determining whether the alteration or extension design is successful or not.

### 4.2 Formal design of alteration and extension of buildings

#### 4.2.1 Formal design of alteration of buildings

1) Maintenance and restoration of the appearance of the original buildings

This method is under the designing principle of maintaining the original historic appearance of the building. In the renovation, the exterior form of the building is under strict protection, and the focus of renovation is inside the building, that is, according to the new utility requirement and the current condition of the building, make readjustment and renewal to the function and form of the building. For some buildings having serious structural damage, people usually remove the interior parts completely and replace them with new architectural technology and material on the condition of preserving the appearance of the building.

2) The formal coordination between the new and the old elements

From the viewpoint of preserving the historic style of the original building, alteration on the whole should respond to the original historic building. The supplement to the damaged part of the original building is not required 100% restoration, but the contrast between the two elements should not be sharp: alteration and the added parts should respond to the original building in form and material, to reach the formal coordination and harmony in the end.

3) The formal contrast between the new and old elements

Now this designing method is used mostly in the developed countries. The aim of alteration is repair and perfection, and usually the light-weight new material and style (such as steel, aluminum allot material,

large glass etc.) are used for supplemented and added parts, which are very different from the grave appearance of the original building; therefore, the formal contrast between the new and the old elements is formed. The principle of the method is neither to wipe out history, nor to make fake antique, but to incorporate the past and the present naturally to produce a style of interweaving between the new and the old.

4) The complete formal renewal

The aim of this renovation is to create new environment image, and it is mainly about being new. Usually the original form is common; however, since the original building is regarded as a container for new function, the building after renovation will take a completely new look.

### 4.2.2 Formal design for architectural extension

1) The coordination between the new and the old forms

Extension project is in accordance with the historic building. It can be divided into two types according to the role of the old and the new forms in extension.

- Formal coordination based on the historic building It is very much like the above coordination between the new and the old elements. From the viewpoint of preserving the historic atmosphere around the original building, prominence should be given to the responding formal element between the extension and the original historic building style. Meanwhile, new material is adopted which is different from that in the historic building.
- Formal coordination based on the new building It can be regarded as a total formal renewal, and the original building is submerged in the new formal style. The renovation is out of economical and environment protective consideration.

2) The contrast between the new and the old forms

It is similar to the above formal contrast between the new and the old elements. The extension part takes on a completely new architectural look, and it contrasts sharply with the historic building in material, color, and shape, reflecting the environment change with time. It shows a kind of designing concept of four-dimensional space, but generally speaking, it maintains the intrinsic individual characteristics of the industrial building.

The recently completed Qijiang Park in Zhongshan, China is one of the few excellent cases of historic industrial sites' regeneration. The site for Qijiang Park is originally the site for Eastern Canton Shipyard, whose heyday was between 1950 and 1980. In 1998, under the background of "moving manufactory out of inner city and replacing it with service industry", it's decided to transform the shipyard into an urban open recreational center with the theme of industrialization. Architects use the old shipyard, transformer, gallow, chimney and cutting machine as designing materials, and make them artistic works, which are full of historical implication. Citizens and tourists can feel the presence of "the beauty of industrial landscape"(see Fig.8).

**Fig**.8 Qijiang Park, Zhongshan, China, an excellent case that witnessed a transition from a shipyard to an urban recreational park with the theme of industrialization

## 5 Conclusion

Generally speaking, most industrial buildings are strong in structure, and their large interior space has flexibility in use. Adaptive regeneration can reduce energy and material consumption to the minimum. Compared with total pull down and total buildup, this development method can reduce the large quantity of construction rubbish and the pollution to the city environment. At the same time, it reduces the pressure on the city transportation and energy in the construction process, following the global trend of sustainable development; adaptive regeneration can also preserve and redemonstrate the cultural value and spirit of those historic buildings.

Meanwhile, an incremental approach to the organic renewal and adaptive reuse should be recommended for those historic heritage buildings and sites. Actually, the approach can involve planning and designing advocacy and it is particularly involved with long-term change. It is seldom static and fixed.

In China, because of the readjustment of industrial structure and the renovation need of city development, the historic industrial buildings and sites are already one of the objects in city redevelopment. Like what happened to the developed countries in their city renewal movement, at present, the destructive development to these kinds of buildings and sites in China are still very serious. By sharp contrast, the regeneration of the historic industrial buildings has received more and more attention in the world.

To save the historic industrial buildings from destruction and regain their lives, we should do something much more than conduct research from academic point of view. The more important is to make the general public, city governors and developers reach consensus on this view, and according to the development of their areas, establish a set of effective operation system involving factors of law and regulation, government and public participation etc.

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# 产业类历史建筑及地段的适应性再利用初探

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**摘　要**　本文分析了产业建筑在城市发展历史上的独特地位.随着城市经济的转型和传统产业结构的调整,在过去30年间的城市更新中,包括中国在内的许多城市经历了一次大规模的产业建筑拆毁和废弃,然而这导致了城市历史文脉和文化发展断层的出现.探讨了产业类历史建筑的分类,中国可以采取的再开发和适应性再利用的方式和措施,为产业类建筑和地段改造再利用提出了一种设计分析框架,同时对今后的实践提出了几点建议.

**关键词**　产业类历史建筑, 遗产, 适应性再利用, 城市再开发

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